STATE OF GEORGIA

BEFORE THE

GEORGIA PUBLIC SERVICE COMMISSION

In Re:

Georgia Power Company's 2019 Integrated Resource Plan and Application for Certification of Capacity From Plant Scherer Unit 3 and Plant Goat Rock Units 9-12 and Application for Decertification of Plant Hammond Units 1-4, Plant McIntosh Unit 1, Plant Langdale Units 5-6, Plant Riverview Units 1-2, and Plant Estatoah Unit 1	)))))))))	**Docket No. 42310**

DIRECT TESTIMONY OF EDWARD T. BORER, JR.

on behalf of

EMORY UNIVERSITY

April 25, 2019

Q. Please state your name, title and address.

My name is Edward Turner Borer, Jr.

My title is energy plant manager for Princeton University ("Princeton"). In that capacity, my business address is MacMillan Building, Elm Drive, Princeton, NJ 08544.

I am also principal for a small engineering consulting firm, Borer Energy Engineering, LLC. That business address is: 278 Wargo Road, Pennington, NJ, 08534.

Q. Please summarize your education and professional experience.

I earned a Bachelor of Science degree in mechanical engineering at Union College, Schenectady, New York, and a Master of Science degree in mechanical engineering at Drexel University, Philadelphia, Pennsylvania.

I maintain professional engineering licenses in the states of Pennsylvania and New Jersey. I hold various professional certifications including LEED accredited professional, and Certified Energy Manager.

I began my engineering career at Philadelphia Electric Company in the Mechanical Engineering Branch of the Engineering Section in 1984. Work effort was split between maintaining and modernizing about six large coal- and oil-fired plants, several dozen gas-turbine peaking and black start units, the Connowingo Dam Generating Station, the Muddy Run Pumped Storage Station, and the Peach Bottom Atomic Power Station. Over the next ten years my assignments continued to be split between the central engineering office and generating stations.

In 1994 I was hired by Princeton University to oversee the construction of its cogeneration plant and continue on as plant manager, responsible for a plant operating staff of 26 personnel.

I have lead engineering responsibility and oversight for all aspects of campus gas, oil, steam, chilled water, electric production and thermal distribution systems and am responsible for overall energy plant performance, economic operation, permitting, code compliance, reliability, and efficiency.

I am actively involved in developing specifications and design oversight for future campus energy upgrades including: a campus-scale district energy heat pump plant, a geo-exchange wellfield, hot and cold thermal storage, battery energy storage, renewable fuel upgrades, solar PV expansion, district hot water, and sanitary water reclaim.

Q. Do you have any other professional roles?

In 2015, I established "Borer Energy Engineering, LLC" in 2015, providing consulting to a range of clients. Most of my work has involved developing and presenting training programs, providing executive-level training, research, and preparing white papers about energy, energy analysis and recommendations for specific energy systems. I have provided technical briefings about energy at state (NJ BPU) and federal (FERC commissioner, US Senate briefing) levels.

Q. Please describe the Microgrid Resources Coalition (MRC), and your role in the MRC.

The MRC is a consortium of leading microgrid owners, operators, developers, suppliers, and investors formed to advance microgrids through advocacy for laws, regulations and tariffs that support their access to markets, compensate them for their services, and provide a level playing field for their deployment and operations. In pursuing this objective, the MRC intends to remain neutral as to the technology deployed in microgrids and the ownership of the assets that form a microgrid. The MRC is actively engaged in advancing the understanding and implementation of microgrids across the country.

MRC members hold significant energy assets connected to the electric grids, provide energy generation and supply services, and are exploring microgrid construction and ownership in different locations throughout the country. MRC members include: Anbaric Transmission, Clearway Energy, Commonwealth Edison, Concord Engineering Group, Eaton, Emory University, ENGIE, Icetec Energy Services, Inc., Massachusetts Institute of Technology, NRG Energy, Inc., Princeton University, Thermo Systems, University of Missouri and the University of Texas. The MRC is affiliated with the International District Energy Association ("IDEA"), which connects members from the United States and other countries operating district energy systems and microgrids.

Princeton University serves as President of the MRC. I was a founding member of MRC and now serve as one of Princeton's two members on its board.

Q. What is the purpose of your testimony?

The MRC is pleased to assist its member Emory University in informing the Georgia Public Service Commission of the benefits of microgrids for utilities and their customers. We support the efforts of the University to partner with Georgia Power to implement a microgrid pilot that explores the value of microgrids in providing resilience to utility systems and value to utility ratepayers.

Q. Please describe what a microgrid is.

The MRC defines a microgrid as "a local electric system or combined electric and thermal system that: (1) includes retail load and the ability to provide energy and energy management services needed to meet a significant proportion of the included load on a non-emergency basis; (2) is capable of operating either in parallel with or in isolation from the electrical grid; and (3) when operating in parallel, can provide some combination of energy, capacity, ancillary or related services to the grid."

Q. Please describe the Princeton University microgrid and how it operates.

The Princeton University campus is served by a microgrid that includes 15 MW of gas-turbine cogeneration in the form of combined heat and power (CHP), 4.5 MW of solar generation, 40,000 ton-hours or about 40 MWh equivalent of thermal storage, advanced building controls, and an advanced interface with the grid. We are connected to the local utility grid through two separate 26KV substations which each have two independent feeds. Our gas turbine and boilers can burn either natural gas or diesel fuel. Natural gas is delivered by our local utility. We store several days' worth of diesel fuel onsite. Half our campus cooling capacity is in steam-driven chillers and half the capacity is in electric-driven chillers – we have built a system with many options. In 2003, power was deregulated in NJ, and industrial and large commercial customers are now exposed to real-time Locational Marginal Cost pricing that fluctuates every five minutes. Similar to a miniature Regional Transmission Operator (RTO), Princeton predictively dispatches all of its major assets including both generation and load on a real-time economic basis. Princeton may dedicate a portion of its generating capacity to providing regulation, an ancillary service that provides balancing energy to the PJM Interconnection, LLC ("PJM") system in under two seconds following a signal from the grid operator.

Q. Why is energy reliability and resiliency important to Princeton?

We have a daytime population of over 15,000 people. We have a high percentage of international students and almost no commuter students, so we are responsible for a large population who are on campus for months or years at a time. The university includes several globally important research laboratories whose work could be set back or ruined if power or environmental controls were lost. The university hosts libraries with rare books, shared book storage facilities, and an art museum with priceless works. We operate a high performance computing research center, which includes both scientific computing as well as university administrative functions. All of these require continuous power and environmental controls.

Q. What utilities does the Princeton University offer to the campus?

Princeton's central energy plant provides three utilities: steam, chilled water, and electricity to the campus. We serve 100% of the heating and cooling needs of the campus and produce about 50% of the electricity used by the campus. The balance of electricity is purchased from PSEG, our local utility. All three forms of energy are supplied 24 hours a day, 365 days a year.

Q. What are steam and chilled water used for in "off seasons"?

In winter, steam is used for building heating. But it is needed 12 months a year for domestic water heating, dishwashing, reheat after dehumidification, as well as research uses such as cage washers, sterilizers and autoclaves. This year-round steam load requirement supports the utilization of a CHP that improves the effective efficiency for the power generation. Chilled water is used for air conditioning in summer, but all year is needed by lasers, electron microscopes, CT-Scan machines, and computer facility cooling.

Q. Describe how the Princeton Microgrid operated during Hurricane Sandy and the community benefits it provided.

In times of crisis, the University microgrid is able to disconnect completely and generate all the power for campus – even when the region around it is dark. As the storm approached the campus, we could see one or more of the utility feeds to campus trip and be restored multiple times. Late on the night of Oct. 29, 2012, Hurricane Sandy knocked out power for the immediate area, including all feeds to campus. Although we have survived similar grid failures in the past, due to the nature of the particular fault, this tripped the university power systems as well. The University was dark for about 20 minutes. PSE&G was able to restore power and Princeton restarted its cogeneration plant. Princeton does have black start capability but did not need to use it in this instance. Since the storm intensity was growing and we saw an increasing number of voltage transients, we had reason to believe the risk to the utility grid was getting worse. Internally, we sought and obtained approval to separate from the utility and run as an island even while utility power was still available.

Shortly after our decision to transition to island mode, the utility tripped again. It was not restored again for a few days. The turbine, now disconnected from the PSE&G grid and running at 13.5 megawatts to avoid overburdening it, powered the campus until the University reconnected with the main grid shortly before midnight on Oct. 31. In the meantime, the University served as "a place of refuse," with police, firefighters, paramedics and other emergency-services workers from the area using Princeton as a staging ground for meetings and charging station for phones and radio equipment. Local residents whose homes lost power also were invited to warm up, recharge phones and other electronic devices and use wireless Internet service, or even sleep at a hospitality center that was opened on campus at the request of the Princeton municipal emergency operations center.

Throughout the storm and in the days after, we were able to keep all heating and cooling operating at full capacity, all mission-critical electric service, and many optional electric services operating. At risk would have been immeasurable decades of research, but nothing was lost.

While Princeton couldn't anticipate Hurricane Sandy 20 years ago when the microgrid was first established, we knew there were things that make the local grid unreliable, and now we can run the campus as an electric island in times of crisis.

Q. What lessons have you and other MRC Members learned about grid resilience and the role of microgrids?

As integrated aggregations of demand and supply resources that can be managed as a unified resource, microgrids are inherently resilient. By operating as micro-control areas islandable from the grid, microgrids provide intelligent load shedding, preserve the functionality of critical infrastructure and aid in grid restoration, and support the local community. In so doing, they project their resilience onto their communities and the larger grid. Microgrids often include distributed generation, storage and advanced building controls that can provide rapid substitution for (or reduction in demand for) grid supplied electricity, and they may also include a wide array of other capabilities such as the ability to transfer heating or cooling load from electric to thermal resources and back, the ability to use buildings themselves as thermal storage, the integration of electric vehicle batteries, and the ability to alter the time of use for many different types of loads. We have learned that having a diverse array of assets and energy sources helps avoid common-mode failures. We do not see microgrids, CHP, building energy management, and thermal storage as better or worse than large central electric-only generating stations, but as natural compliments to the larger system. We have learned that at some times, we can produce and deliver power to the university at much lower cost than if we purchased it from the utility. At other times, we can offer the utility our own excess power at a price higher than our marginal cost, but less expensively than they could buy it from utility or merchant plants. We have learned that by thoughtfully dispatching our generation and load, we can lower life-cycle costs and lower net CO_2 emissions.

The MRC believes it is important that any definition of resilience must recognize that resilience for our society manifests in our communities.

Resilience is not the same as reliability, and we suggest that a good working definition is: “The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such events the functioning of critical infrastructure to sustain essential services for communities during and following such an event." The ability to power the infrastructure necessary to maintain critical services to our communities is the ultimate measure of performance.

For the MRC, microgrids represent a class of uniquely resilient resources that employ hybrid generation, intelligent load management, and sophisticated controls to safeguard and manage included load and provide sophisticated services to the grid. We believe that utilities can achieve grid resilience by using microgrids and other flexible, visible "grid edge" resources as building blocks and by investing in distributed communication and control elements that allow the reconfiguration of the distribution system in response to disturbances so that microgrids can support one another and the larger grid.

The MRC recognizes that there are opportunities where microgrids can be more cost-effective, non-wired alternatives to providing reliability and resilience while mitigating congestion at stressed grid nodes.

Communities and customers are the best judges of where resilience matters most. They understand their critical needs for health, safety, and the preservation of economic activity. By contrast, reliability analysis of the bulk power system treats all local uses alike – no distinction is made between cooling a movie theater, a critical care nursing facility or refrigerated research specimens – and collective measures such as aggregate loss of load or average outage duration do not capture resilience where it matters. The goal of resilience planning must be to ensure that the entire grid system works to protect our communities. Communities, customers, and state and local authorities must be involved in planning and implementing resilience solutions.

Microgrids distribute, diversify, and reduce risk rather than concentrating it at a few large generating stations or critical grid nodes.

Q. Does Princeton own or operate any other microgrids?

Yes. Our university data center is located about three miles away from the main campus. Data centers rarely need heat, but they need a lot of power and cooling. Reliability is mission-critical, so we installed a reciprocating gas engine and combined it with an absorption chiller. The gas engine can produce 1.9 megawatts and the absorption chiller can produce up to 600 tons of cooling, powered by the waste heat from the gas engine's jacket water and exhaust stream. Like the main campus cogeneration system, this is 70-80% efficient and can be dispatched economically, or used in combination with a traditional diesel generator to support the data center in island mode during emergencies.

Q. Who typically owns microgrids?

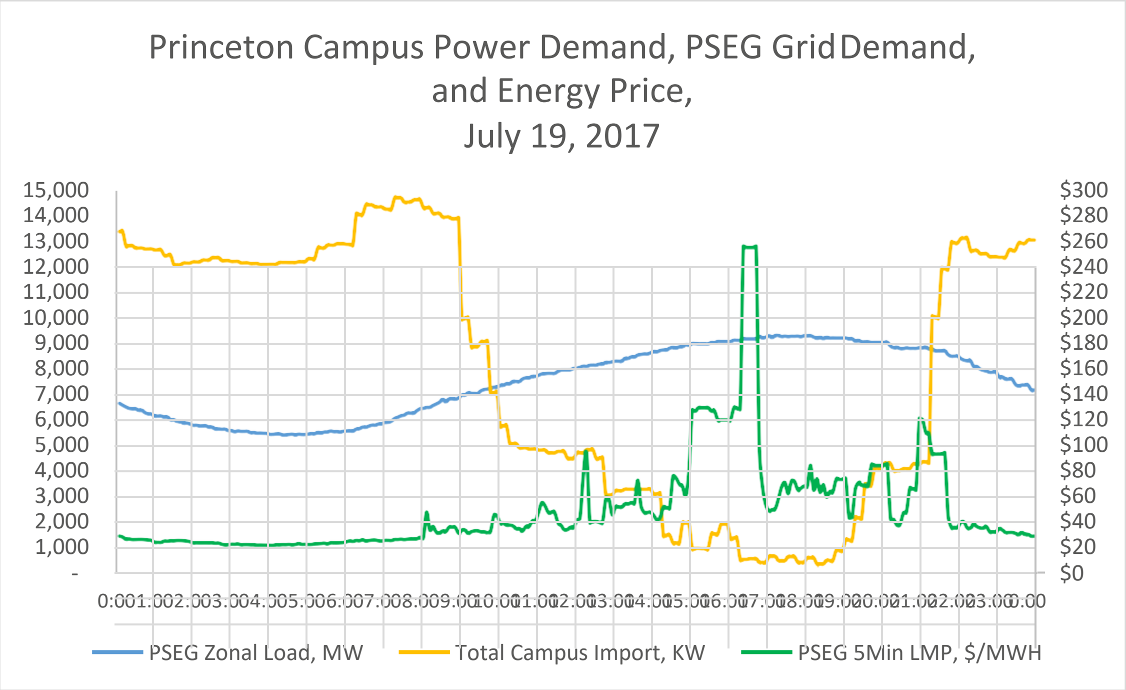
Microgrids may be developed and operated by a variety of parties. Princeton is a single private, not-for-profit electric customer that owns its microgrid. Rutgers University is a public institution that owns and operates a CHP-based microgrid. The nearby Princeton Medical Center has a microgrid operated for its benefit, which is owned and operated by NRG. Local for-profit pharmaceutical companies such as MERC, Novartis, and Bristol Meyers Squibb own and operate microgrids. New Jersey's capital city of Trenton has a municipal microgrid that produces steam, chilled water, and some electricity. Microgrids and combined heat and power are common at airports, hospitals, prisons, military bases, research campuses, and universities – all places where efficiency, reliability, and resilience are highly valued.

Q. Are there challenges to building a microgrid with multiple off-takers?

In many jurisdictions, it can be very difficult to organize an efficient aggregation of customers to support a multi-customer microgrid or other distribution-level resource because of limitations on retail sales of electricity. In these jurisdictions, a microgrid can be developed as a utility-private partnership, in which the distribution utility owns the wires and meters the retail customers, but generation and other operating services are provided by customers or third parties. This is being done in the Hudson Yards project in New York City in collaboration with Con Ed. We understand that Emory and Georgia Power have discussed a microgrid with various elements, some of which could be owned by Emory, some of which could be owned by Georgia Power, and some which could be owned by a third party.

Q. Describe how Princeton's microgrid reduces system demand in times of system stress.

The figure below shows (a) aggregate wholesale market energy consumption, (b) the wholesale energy price for the service territory of PSEG (the electric utility serving Princeton) and (c) the Princeton Campus energy purchases from the grid, all plotted against the time of day. The data is for July 19, 2017, one of the days when the entire regional grid operated by PJM was near system peak capacity.



Note that system load and campus imports use the same left margin scale, but system load is in MW and campus imports are in kW.

The chart shows that Princeton purchased a substantial amount of electric energy in the early morning to charge its thermal storage – chilled water in an insulated tank. It then purchased almost no electric power at the time of peak usage and peak pricing on the PJM system. This result at peak was achieved by that thermal storage, 15 MW of cogeneration and 3.75 MW of solar.

Normally, campus load peaks at around 27 MW. During the grid peak it was reduced to around 1.9 MW through use of solar power, cogeneration, steam-driven chillers supplied by heat from the cogeneration plant and discharge of chilled water from the thermal storage tank. Princeton avoided purchasing high priced power and helped to reduce its transmission charges. Collective control of multiple grid edge resources allows Princeton to manage for efficiency, price, and reduced carbon.

Q. Is there a simple over-arching concept that you can use to describe what Princeton's microgrid does from the utility standpoint?

Princeton's microgrid is a collection of assets that we use to control our apparent demand at the meter; our load shape. In general, we invert the typical customer's demand curve. We purchase a lot of baseload power at night and on weekends. We tend to avoid the purchase of power when the grid is most stressed during peak hours. This helps us manage both life-cycle cost and carbon footprint. It also provides greater resilience to the campus.

Q. One test of sustainability is "If everyone did what you do, would that work out well, or would it fail?" How does Princeton's microgrid address this test?

As more microgrids are built with the ability to manage generation and loads and they are given appropriate economic signals, they will tend to purchase more baseload power when it is inexpensive and the grid is least stressed. They will tend to avoid purchasing power when prices are highest and the grid is most stressed.

Q. How can Georgia Power and Emory take advantage of these sorts of services?

Networked distribution systems with smart metering and local resource controls are more resilient. They can substantially reduce system restoration costs and, by reducing the size of critical components, can realize savings on the costs of reserves. Intelligent load shedding (achievable in multiple ways by unified resource aggregations such as microgrids), and islanding can substantially reduce the costs of disruptions for both the system and for customers.

Where local resources can improve the stability of a substation or decrease pressure on a radial circuit, or support essential community and distribution grid control services, the MRC has suggested that the distribution utility issue a Request for Proposals for resources that can provide "distribution support services" on a mid- to long-term contracted basis as a more resilient alternative to the distribution utility implementing a traditional physical system capacity upgrade (often called a "wires solution"). The California Public Utilities Commission has taken the lead in requiring that distribution utilities identify the locations on their system where distributed energy resources can make a contribution and is exploring how to compensate distribution utilities so that they are indifferent between the distribution support service solution and the wires solution. The Potomac Electric Power Company's filing with the Maryland Public Service Commission, for public purpose microgrids, proposes to acquire generation resources for the microgrids through RFPs and to treat the contracts for microgrid generation services as regulatory assets. The MRC supports these approaches.

Q. Are there other ways that the Princeton microgrid provides benefits to PSEG ratepayers?

We raise our generation output and reduce demand whenever the cost of purchasing power is higher than our marginal cost of generation. By self-dispatching on an economic basis, Princeton's microgrid effectively lowers the net cost of power for all customers. Also, by generating more power and demanding less during peak demand times and storms, we effectively reduce stress on the grid when it is most stressed. Through our use of thermal storage, we increase use of baseload utility generation and avoid use of peaking generation – reducing capacity requirements for the utility.

PSEG is also our local distribution utility for natural gas. We have an interruptible natural gas contract. So during the most extreme winter weather, or if there is a pipeline problem, they will call us up and ask us to discontinue all use of all natural gas so they can meet the peak needs of local retail customers. We switch to our backup fuel, #2 ultra-low sulfur diesel. Very similar to electricity, we are able to use a lot of gas when it is least in demand, and avoid the use of gas when the transmission and distribution systems are most stressed. This saves us money and allows PSEG to operate their gas transmission and distribution systems at a higher capacity factor all year.

Q. Describe your relationship with PSEG.

We have an excellent relationship with our local utility. They meet with us at least monthly to review all key items including both physical projects and contractual issues. We are in regular communication about outage planning (ours and theirs). They regularly use our microgrid as a place to show other customers what is possible and to train their own executives about microgrids. On rare occasion, they have contacted us about grid issues and asked if we can change our generation output or demand to support them. Princeton and PSEG are actively collaborating on a project with PJM to develop a real-time locational marginal emissions signal.

Appendix

For illustrations of how microgrids may support the resilience of the grid, please refer to the following examples of resilience during major storms. This list was compiled by the International District Energy Association ("IDEA") and described in its comments on Docket No. RM18-1-000 of the Federal Energy Regulatory Commission, Grid Reliability and Resilience Pricing, filed October 23, 2017.

1. Co-op City is a residential development home to roughly 50,000 people in the east corner of the Bronx. After the 2003 blackout, Co-op City invested in a microgrid served by a 40 MW CHP facility. During Superstorm Sandy, Co-op City was able to reliably provide electricity, heat, and hot water to its 50,000 residents without interruption. In the aftermath of Sandy, Co-op City helped restore the grid by providing black start services to Consolidated Edison.
2. Nassau Energy has a microgrid supported by a 57 MW CHP facility. During Superstorm Sandy, Nassau Energy provided power to the Long Island Power Authority, helping with restoration efforts. Furthermore, Nassau Energy provided thermal energy to the Nassau University Medical Center and the Nassau Community College during Superstorm Sandy. In part because of Nassau Energy's services, the Medical Center was able to attend to several patients displaced from nursing homes during the storm, and the Community College served as an emergency shelter that provided services to over 1,000 people displaced by the storm for over one month.
3. The College of New Jersey has a microgrid supported by a 5.2 MW CHP facility. The College operated in island mode during Superstorm Sandy and maintained electric service despite grid disruptions. In the aftermath of the storm, the College was able to use its equipment to back-feed one of PSEG's power lines to bring it back to service.

4. The Danbury Hospital (Danbury, CT) has a microgrid supported by a 4.5 CHP unit that provides the buildings at this 371 bed hospital with electric power and heat. The Danbury Hospital was able to withstand Superstorm Sandy due to its ability to operate in isolation from the utility grid during the storm and continued to admit patients from other sites that were forced to close due to the storm.
5. The South Oaks Hospital (Amityville, NY) has a microgrid supported by a 1.25 MW CHP facility. During Superstorm Sandy, the Hospital isolated itself from the grid and was able to provide critical services for two weeks relying solely on its CHP system. The hospital admitted patients from other sites that had been displaced by the storm and offered refrigeration of vital medicines to those who had lost power and had no other means of keeping their medicines refrigerated.
6. New York University (New York, NY) has a microgrid supported by a 14.4 MW CHP facility. During Superstorm Sandy, the NYU microgrid provided uninterrupted electric service, heating, and cooling to the campus, which served as a command post for New York City officials during the storm and served area residents that had been forced to evacuate their homes.
7. The Louisiana State University ("LSU") (Baton Rouge, LA) has a microgrid supported by two CHP facilities totaling approximately 24 MW of nameplate capacity. LSU stayed online and never lost power during Hurricane Katrina in 2005, and again during Hurricane Gustav in 2008, allowing the campus to be used as shelter for many employees that had been displaced by the hurricane.